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On Regional Variations in the
Plankton of the Illinois River

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ON REGIONAL VARIATIONS IN THE PLANKTON
OF THE ILLINOIS RIVER

BY

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ON REGIONAL VARIATIONS IN THE PLANKTON OF THE ILLINOIS RIVER.

The collections which form the basis of the present paper were obtained during a trip on the Illinois River which was made between May 18 and 21, 1899. The work of taking the collections was in charge of Dr. C. A. Kofoed, then Superintendent of the Illinois Biological Station. The undertaking was made possible through the courtesy of the Board of Fish Commissioners of Illinois, on board whose Steamer, "The Reindeer", the collecting party worked. Owing to the exigencies of the occasion the collections were made by the use of improvised apparatus. This consisted of a piece of 1-1/2 inch pipe, with the orifice, reduced to 3/4 inch, situated about 18 inches under the surface of the water and directed up stream. The collecting pipe delivered, as the boat went forward, a continuous stream of water into the plankton net which was suspended in a barrel set on the fore guard. The net employed, with attachments, was the one regularly in use at the station in the work with the plankton pump, and has been described by Kofoed ('97).

The collections made compose a practically continuous series for a river length of 220 miles, or the distance from Grafton to Hennepin, interruptions occurring only at 10 mile intervals for the purpose of transferring the catches to the killing and preserving fluid. The individual collections may be looked upon as longitudinal sections of the stream, each catch representing, not the material obtained in a particular locality, but an average for a distance of about 10 miles. In the preservation of the material and in its examination and study the methods hitherto in use at the Biological Station and described by Kofoed('97) have been followed. In enumerating the contents of the different catches the amount counted

varied with the volume of silt and plankton present, from 1/400 to 1/50 of the total contents of the catch in the case of the Algae, Protozoa, and Rotifera; while the amount was increased for the Entomostraca to from 1/100 to 2/25 of a total collection.

In consequence of the methods used and other peculiar conditions attending the work of taking the collections the amount of water delivered by the collecting pipe was subject to greater or less variation. The principal factors in such variation must have been (1) the clogging of the net; (2) the distance traversed in making the catch; (3) the speed of the boat; (4) the speed of the current. The boat was run at a uniform speed so far as that could be controlled, this approximating 15 miles per hour. The catches were planned to cover as nearly as possible distances of 10 miles each, the distance traversed having been left in all cases to the pilot. To prevent clogging the net was repeatedly shaken down so far as this was possible with attention to other duties. Clogging is no doubt the chief factor to be considered in explanation of whatever differences in amount strained occur, since waters characterized by considerable differences of turbidity and plankton content were encountered in the course of the trip. Because of lack of time it was impossible to make the number of tests of the amount of water strained in a given time that are requisite in order to insure a means of correction for clogging. Because of the inadequacy of the tests made the work of determining and enumerating the contents of the collections and the study of the results have been undertaken without first making such correction, on the supposition that the amount of water strained in the various catches was, roughly speaking, uniform. It is obvious that an accurate correction for clogging

would scarcely alter the nature of the more general results obtained, but would only serve to bring into more striking contrast the enumerations made for the different regions of the river, since in those places where the maximum amount of plankton was encountered the amount of water strained was doubtless least owing to the clogging of the net by a silt-laden and plankton-rich in-flow.

The Environment of the Plankton.

The 220 miles of the river traversed may be separated on a basis of local physical conditions into three more or less distinct regions. These are (1) from Hennepin to the north end of Peoria Lake, 40 miles; (2) from the north end of Peoria Lake to Havana, 50 miles; (3) from Havana to the mouth of the Illinois at Grafton, 130 miles. The three sections are more or less sharply separated from one another by differences in the amount of organic waste carried, in the size, capacity for plankton production, or diluting effect of tributary lakes and streams, and in the amount of rainfall and ensuing rain-flow just before or during the trip. The differences of depth, speed of current, and temperature in the three sections appear to be of such slight amount when compared with those first mentioned that they may well be disregarded.

At the time of the trip, which was made 7 months before the opening of the drainage Canal, the upper section was receiving its ordinary contribution of organic waste, made up chiefly of the residue of the Chicago sewage pumped into the DesPlaines River at Bridgeport, to which is added the waste from the upper river towns and some quantity of detritus and seepage from the neighboring cultivated land. The contribution of sewage to the middle section is made up largely of the house and stock-yards waste and factory

refuse discharged into the river at Peoria. The lower section is comparatively free from sewage, the amount coming in from the lower river town being scarcely appreciable. A progressive diminution in contamination from above southward characterizes the upper section, the average of parts per million of free ammonia carried between July 4 and December 7, 1899 being 3.28 at Henry and 0.895 at Peoria Narrows, immediately above the city of Peoria. (Long, 1900). Determinations by Jordan (1903) made between May 24 and 31, 1900, show a similar variation in the number of colonies of bacteria per cu. cm., the date approximating very closely the time of the plankton trip (May 18 - 31). The ingress of sewage at Peoria is plainly shown by the great increase in contamination that the water undergoes between Peoria and Wesley City, one hundred and thirty miles below, the free ammonia average for July - December, 1899 being 4.36 parts per million at Wesley as compared with 0.895 at Peoria Narrows. (Long ib.). The decrease in contamination is quite rapid between Peoria and Pekin, the free ammonia average at both Pekin and Havana being about 1/3 the average for Wesley City. The count of colonies of bacteria (Jordan, ib.) shows 832,000 per cu. cm., at Wesley on May 29, with but 4,500 at Havana on May 30. There is in the lower section, if a few slight variations be excepted, a slight progressive decline of contamination to the mouth of the river. The decrease between Havana and Browning (30 miles below) is indicated by a fall in the free ammonia from 1.69 to 0.143 parts per million, while the amount at Grafton, at the mouth of the Illinois, is slightly higher than this (Long, ib.).

The three regions are further distinguished by their relations to communicating lakes and streams. Of the first it may be said that

they are abundant in the middle section, few in the upper, and rare in the lower. Senachwine and Mud Lakes which are just above Henry and which comprise an area of about 3-1/2 sq. miles, include practically all the lake area in communication with the main stream in the forty miles above the north end of Peoria Lake. The middle section is distinctively the lake-fed portion of the river. In the 50 miles between the north end of Peoria Lake and Havana there are upwards of 20 lakes of considerable size contiguous to the river and discharging into it in flood season or at all except dry periods. These lakes roughly approximate a surface area of 25 square miles, for a river length of 50 miles, in evident contrast with the lake area of but some 10 or 12 square miles in the entire 120 miles below. A number of the lakes of the middle section are known to be rich in plankton when the season is favorable to its development. The failure so far to examine collections from representative lakes in any but the middle section makes impossible any comparison of the plankton producing qualities of the lakes of the three sections.

The tributary streams in the upper section are so small and so few that dilution from them is hardly considerable. In the middle section Kiskadee, Mackinaw, and Copperas Creeks add quite appreciably to the dilution. Long estimating that 13.8% of the flow at Havana during summer is obtained ordinarily from these three streams and others of lesser importance. Of the tributary streams in the lower section the Spoon and Sangamon are of most importance. At Pearl (80 miles below Havana) Long finds that about 40% of the water of the Illinois is from the Spoon and Sangamon and doubtful sources located in the region between Pearl and Havana.

The rainfall in the Illinois Valley during the four days pre-

celing the collecting trip was so distributed as to lead to a congestion of flood water in section two at the time when collections were made. On these days (May 18 - 19) there was a heavy rainfall throughout the northern part of Illinois, extending southward to Joliet, Ottawa and Henry. On May 20, when the upper 40 miles of the trip was being made, the river in this region had cleared decidedly, as is shown by the disc readings, and the silt and detritus had been mostly carried down into the middle section. The muddy character of the collections taken in and just below Peoria Lake is the farthest northward evidence of the effects of the north river rains of the four days previous. The rainfall in the middle section on the four days preceding the beginning of the trip was considerably less than that in the region above. In the neighborhood of the south region there had been a very general absence of rainfall on these same days. The turbid water coming southward was not encountered in the thirty miles above Grafton; but the disc readings and the muddy character of the catches from Grand Pass to Havana show a noticeable increase in turbidity.

The Plankton and its Fluctuations.

The plankton of the river, as represented in the collections made on the trip, includes a miscellaneous list of Algae, Protozoa, Rotifera, and Entomostraca, aggregating 121 forms, along with various other organisms of microscopic size. In the present paper attention will be directed to the first four groups only. A total of 28 species belonging to the phyto-plankton were determined, the number of species found in single collections varying between 10 and 21. No significance can be attached to these differences, it being probable

that an examination of a larger amount of material from these stations which appear to be low in number of species would have resulted in materially increasing the range of forms listed. The same remark applies to the less abundant species of the other groups. The Protozoa identified in the collections aggregate a total of 43 species, the Rotifera 42, and the Entomostraca 17. Numbers used in the discussion that follows are totals per collection, which may be regarded as approximating roughly 1 cubic meter.

In the upper section we meet with relatively low production in the phyto-plankton. The totals of Algae here range from 4,800,000 to 6,300,000, as compared with 19,500,000 to 21,000,000 in the region below. The middle region, then, is distinguished by a remarkable production of Algae, as it is also in respect of the amount of the plankton in practically all of its elements except the Protozoa. The high figures reached by the Algae in this region are due largely to the immense production of a filamentous diatom, Melosira granulata, var. spiculosa, which comprises in most collections from 80 to 95% of the quantity of Algae present. In the region between Pekin and the north end of Peoria Lake, which is the extreme upper portion of the middle section, this species attains its maximum of 27,717,000, which numbers are about 20 times the average for the upper section, nearly 4 times the largest number from any collection below it, and 40 times the average of the collections from the 80 miles above Grafton. The rise in the Algae from 6,078,300 at Chillicothe, in the south portion of region 1, to 21,087,500 in the Peoria collections is followed by a fall to 23,454,800 at Pekin, while from Pekin to Havana but slight diminution is undergone. The decline in numbers in the lower section, which is also as far as Peoriatown,

the third station below region 2, becomes more rapid further southward, culminating at Grafton in a total of 2,654,000, which is but a little more than $1/9$ of the average for section 2, and but about $1/38$ of the maximum of Algae reached in the Peoria region. The fall off in the direction of Grafton includes all species that occur in numbers of any considerable importance.

The distribution of the Protozoa seems to be essentially irregular. But small numbers of Protozoa occur in the collections, and no very significant differences in abundance can be made out for the different sections of the stream. Gedonella cratera and an unknown black-shelled rhizopod constitute, as a rule, the larger part of the Protozoa in the collections, and these two forms are quite aberrant in their distribution. About 40 other species occur in small and scattering numbers.

The fluctuations in the rotifer-plankton follow, somewhat tardily, those of the Algae, the maximum of the middle section giving way to the decline further southward. The Peoria collections are but very little larger than those from the lower end of the middle section. The totals for the region of maximum, 678,200 for Peoria and from 307,600 to 588,700 in the four collections below, are significantly large when compared with 194,000, the largest number found above or below the region of maximum, with 74,000, the average for the upper 30 miles of section 1, and with 66,000, that for the lower 30 miles of the river.

In the upper section the average production of Entomostraca is but little more than $1/3$ of that for section 2. All of the commoner species are noticeably rare here. While the maximum of Entomostraca is reached in the middle region, the Peoria collections are but



little larger than those from the lower portion of the middle section and the fall off in production in the lower section is much less rapid than in the case of the Rotifera and Algae. This shifting southward of the region of maximum is participated in by all except species of scattering occurrence. The more marked decline of the lower 50 miles of section 3 is also general, and is by no means confined to a few preponderant species.

For the details of the distribution and relative abundance of the individual species of the plankton reference may be made to the lists which follow. Of the total of 21 collections all from the middle section, and alternate collections from the upper and lower sections were counted in detail. Totals of Leptodermis and Enterostrum were obtained for all catches, while the count of Helosira granulata, var. spinosa also extended to all collections. Totals of cells are given in the case of Fragilaria, Asterionella, Helosira (2 species). The number in parenthesis following the names of species in the list indicates the number of collections in which the species was found. The range in numbers in each section and the average for the collections counted from each section are also given in cases where the numbers have a significant bearing. Species which attain considerable numbers and attain their maximum or their highest average in the middle section are double underlined. Forms which occur in numbers of importance, but which reach their maximum or highest average in another than the middle section, are starred. All other species are understood to have been found in but small numbers or to be of rare and scattering occurrence.

Kirchneriella (?) sp. Middle section. (1).

Pellistrum boryanum Men. Upper section (4); 3,600 - 7,200; av. 5,200. Middle (5); 4,000 - 28,800; av. 15,840. Lower (8); 320 - 2,400; av. 932.

Pellistrum parvum Kz. Upper (4); 12,000 - 21,600; av. 16,800. Middle (5); 48,200 - 276,000; av. 132,800. Lower (12); 800 - 57,200; av. 19,025.

Coelastrium sp. Very rare.

Actinastrum hantschii Lagerh. In most collections, but rare.

*Scenedesmus mediterraneus Gr. 1. 8,000 - 14,400; av. 11,200; rare elsewhere.

Scenedesmus obliquus Kg. (2).

Scenedesmus bijugatus Kg. Middle (1).

Raphidium polymorphum Fres. In small numbers in several collections.

*Closterium acerosum Ehrbg. Upper section (4); 5,400 - 14,400; Rare in middle and lower sections.

*Closterium lunula Ehrbg. Distributed much as the preceding.

Staurastrum sp. Upper (1).

Cosmarium constrictum Del. In two collections from upper portion of middle section; 3,600 - 115,200.

Navicula sp. Upper (3); 3,600 - 21,600; av. 10,800; Middle (5); 7,200 - 28,800; av. 14,880; Lower (6); 3,600 - 36,000; av. 10,800.

The error introduced by counting is here large, less than the usual sample having been counted owing to the small size of this diatom.

Pleurosigma sp. (4).

Encyonema prostratum Ralfs. (2).

Gomphonema sp. Lower section (1).

Cymatopleura solea Bréb. (5).

*Gurirella splendida Ag. (14). Numbers small; slightly commonest in upper section.

Diatoma vulgare Dory. (7). Upper and lower sections only.

Meridion circulare Ag. Lower (1).

Synedra acis Kr. Upper (8); 61,000 - 90,000; av. 77,722. Middle (5); 43,200 - 115,200; av. 73,440. Lower (6); 10,800 - 36,000; av. 21,766.

Fragilaria virescens Ralfs. Upper (3); 70,200 - 1,600,000; av. 590,533. Middle (5); 340,200 - 1,534,000; av. 901,140. Lower (6); 10,000 - 195,000; av. 88,616.

*Asterionella gracillima Heib. Upper section 21,600 to 91,200; rarer in middle and lower.

Melosira varians Ag. Upper (3); 115,900 - 276,000; av. 185,233. Middle (5); 212,100 - 2,023,600; av. 1,134,540. Lower (6); 6,600 - 196,600; av. 73,700.

Melosira granulata, var. spicosa Schödler. Upper (4); 2,857,300 - 5,549,000; av. 4,084,775. Middle (5); 18,291,300 - 87,717,600; av. 34,352,240. Lower (12); 1,602,100 - 23,616,000; av. 7,821,418.

Oscillatoria sp. Lower section (2).

Merismopodia clausa Näg. Identified in three collections from upper and lower sections.

THE PROTOZOA.

Amoeba verrucosa Ehrbg. (1).

Arcella vulgaris Ehrbg. (12). Numbers small; maximum in middle section.

Arcella discoides Ehrbg. (14). Distributed as preceding.

*Arcella (?) sp. Upper (3); 3,600 - 6,000; av. 4,800. Middle (5); 6,800 - 57,600; av. 21,280. Lower (11); 8,700 - 147,600; av. 50,245. The stirring up of bottom ooze may possibly account for the large numbers reached by this species and Colonnella cratera (see below) in the lower portion of section 3.

Diffugia lobostoma Leidy. (14). Maximum of 11,200 reached in middle section. Numbers considerably smaller in upper and lower.

Diffugia globulosa Duj. (9). Numbers small; largest in upper section.

Diffugia pyriformis Perty. (4). Rare.

Diffugia urceolata Cart. (13). Numbers small; largest in middle section.

Diffugia corona Wall. (4). Rare.

Diffugia constricta Ehrbg. Upper section (1).

Diffugia acuminata Ehrbg. Lower section (1).

Centropixis aculeata (Ehrbg.). Rare.

Centropixis aculeata, var. ecornis Leidy. (4). Rare.

Euglypha alveolata Duj. (3).

Trinema enchelys Ehrbg. Lower (1).

Cypholera ampulla Leidy. (3).

Actinophrys sol Ehrbg. Lower (1).

Diplosira frequentissima Zach. On Asterionella crassilima. Not abundant. Count of this species not included in totals of Protozoa.

Euglena viridis Ehrbg. (3). Rare.

Euglena oxyuris Schmaria. (5). Rare.

Euglena ~~sp.~~ Ehrbg. (1).

Trachelomonas acuminata Schmaria. Identified in collections

from lower section.

Lepocinclis ovum Ehrbg. (1).

Phacis pleuronectes (O.F.Miller). (3). Rare.

Phacis longicauda (Ehrbg.). Found in 10 collections in very small numbers.

Dinobryon sertularia Ehrbg. Rare, in upper and lower sections.

Mallomonas sp. Seen in collections from lower section.

Synura uvella Ehrbg. (14). Numbers small; largest in upper section.

Syncrypta volvox Ehrbg. (1).

Carteria sp. Present in small numbers in most collections.

Pandorina norum Ehrbg. (2). Rare; middle and lower sections.

Volvox aureus Ehrbg. (2); upper and lower.

Eudorina elegans Ehrbg. (3). Numbers very small; found in all three sections.

Ceratium hirundinella O.F.Miller. (3).

Didinium nasutum O.F.Miller. (1). Lower section.

Paramecium sp. (1).

Codonella cratera Leidy. Upper (4); 4,200 - 19,200; av. 9,600. Middle (5); 14,400 - 64,000; av. 31, 640. Lower (11); 7,200 - 57,200 av. 31, 472. See note on Arcella sp., above.

Tintinnidium fluviatile Stein. Rare.

Euplotes patella Ehrbg. (1).

Vorticella. Detached heads of various Vorticellidae seen in small numbers in most collections.

Zoothamnium arbuscula Ehrbg. (2).

Oothurniopsis vaga (Schrank.) Or Cyclops, in small numbers, in a few collections from upper and middle sections.

Metacinet mystacina (Ehrbg). Lower section (1).

THE ROTIFERA-

*Conochilus unicarria Rousselet. Maximum of 24,100 reached in extreme lower portion of section 2. Highest numbers in middle section in single collection, 4,080. The explanation of these facts is obscure.

Philodina sp. (3). Rare.

Rotifer vulgaris Schrank. (1). Upper.

Rotifer tardus Ehrbg. (10). Numbers small; maximum in upper section.

Rotifer neptunius Ehrbg. (6). Rare.

Asplanchna brightwellii Gosse (11). Numbers small; largest in middle section.

Asplanchna herrickii de Guerne. (3). Rare.

Asplanchna priodonta Gosse. (14). Well defined maximum (11,200), and average of 7,440 in middle section.

Asplanchna ebbesbornii Hudson. (2). Rare.

Synchaeta pectinata Ehrbg. (6). Middle section (3); 400 - 3,200; av. 1,446. Very rare in upper and lower sections.

*Synchaeta stylata Wierz. (4). Middle section, 800 - 2,000. Highest numbers in single collection (3,800) in lower section.

Synchaeta sp. (13). Upper (2); 3,200 - 6,000; av. 4,600. Middle (5); 8,800 - 76,800; av. 24,400. Lower (6); 900 - 45,000; av. 10,100.

Polyarthra platyptera Ehrbg. Upper (3); 5,400 - 7,400; av. 6,266. Middle (5); 7,200 - 27,000; av. 20,560. Lower (6); 1,000 - 11,400; av. 5,300.

Triarthra longiseta Ehrbg. Upper (3); 1,900 - 3,600; av. 2,700.

Middle (5); 3,200 - 18,400; av. 11,680. Lower (6); 400 - 18,800; av. 4,088.

Notops sp. Lower section (1).

Diglena forcipata Ehrbg. Lower (1).

Diglena circinator Gosse. Upper (1).

Rattulus tigris O.F. Miller. Lower (1).

Euchlanis dilatata Ehrbg. Upper section (2).

Monostyla lunaris Ehrbg. (4). Upper and lower section. Rare.

Monostyla bulla Gosse. (3). Rare, Lower section.

Metopidia solitus Gosse. (3) Lower section. Very rare.

Pterodina patina Ehrbg. Seen in two collections from lower section.

*Brachionus pala Ehrbg. (8) Numbers small; slightly highest in upper section.

Brachionus pala, var. amphiceros Ehrbg. Upper (3); 6,400 - 48,800; av. 24,088. Middle (5); 78,000 - 254,400; av. 143,280. Lower (6); 200 - 1500; av. 666.

Brachionus rubens Ehrbg. (3). Numbers small; slightly largest in section 1.

Brachionus angularis Gosse. Upper (3); 2,400 - 9,000; av. 5,300. Middle (5); 70,400 - 212,800; av. 151,680. Lower (6); 6,800 - 74,000; av. 27, 183.

Brachionus angularis, var. lidens Plate. Upper (3); 200 - 6,800; av. 4,700. Middle (5); 8,000 - 19,200; av. 14,400. Lower (6); 200 - 14,700; av. 4,688.

Brachionus militaris Ehrbg. (4). Rare; middle and lower section.

Brachionus variabilis Hempel. Lower section (2). Very rare.

Brachionus bakeri Ehrbg. (6). In small numbers; most numerous

in middle section.

Brachionus bakeri, var. brevispinus Ehrbg. Upper (3); 1,300 - 1,800; av. 1,633. Middle (5); 800 - 10,800; av. 6,240. Lower (4); 100 - 900; av. 375.

Brachionus bakeri, var. obesus Barrois et Daday. Middle section (2), 1800 and 4,800; rare in upper section.

Brachionus bakeri, var. sinuatoangularis Seville. Upper (3); 600 - 4,200; av. 1,933. Middle (3); 3,600 - 5,600; av. 4,400.

Brachionus bakeri, var. rhombus Lauterborn. Upper (3); 400 - 7,200; av. 3,200. Middle (5); 3,200 - 10,400; av. 7,600. Lower (4); 100 - 800; av. 475.

Brachionus bakeri, var. kolbeli Barrois et Daday. (12). In general rather small; somewhat largest in middle section.

Schizocerca diversicornis Daday. Middle section (1).

Amuraea hypelasma Gosse. Rare.

Amuraea cochlearis Gosse. Upper (3); 9,000 - 19,500; av. 13,733. Middle (5); 18,000 - 105,600; av. 48,080. Lower (3); 7,100 - 52,100; av. 21,750.

Amuraea cochlearis, var. teeta Gosse. Rather rare; most abundant in middle section.

Amuraea aculeata Ehrbg. Distributed much as the preceding; not common.

Netholea acuminata - rugosa Wierz. Upper section (1).

Pedalion nigrum Hudson. (4). Rare and of scattering occurrence.

THE ENTOMOSTRACA.

OSTRACODA.-- Present in small numbers in most collections. No attempt made to determine species.

CLADOCERA.

Diaphanosoma brachyurum (Lievin). Middle and lower sections (3).

Moina micrura (Jurine). Lower section.(2).

Ceriodaphnia scitula Herrick. In all collections. Upper, 75 - 125; middle, 1,100 - 6,200; lower, 800 - 7,800.

Scapholebris micronata O.F.Müller. Seen.

Simoccephalus serrulatus Koch. Lower section (3).

Daphnia jardinei Baird, varieties. Distribution similar to that of Ceriodaphnia scitula, but numbers smaller(50 - 1200).

Bosmina longirostris O.F.Müller. Present in all collections. Upper, 1,100 - 2,200; middle, 3,900 - 16,400; maximum immediately above Havana; lower, 1,450 - 11,650.

Alona quadrangulata O.F.Müller. Upper and middle sections, rare.

Alona affinis Leydig. Found in upper and middle sections; rare.

Chydorus sphaericus O.F.Müller. In all collections. Upper, 300 - 475; middle, 1,300 - 3,100; lower, 100 - 2,300.

COPEPODA.

Diaptomus. Scattering occurrences.

Canthocamptus. Lower section.(1).

Cyclops. In all collections. Upper, 2,325 - 6,000; middle, 7,200 - 27,400; lower, 1,200 - 18,400. Five species were determined, the commonest being C.viridis, var. brevispinosus Herrick, and C.edax Forbes.

Nauplii - chiefly of Cyclops. Present in all collections. Upper, 18,000 - 56,400; middle, 36,000 - 122,400; lower, 1,680 -

62,63. The maximum of Nauplii is reached in the lower collections, while in all other cases the Entomostraca reach their highest figures just below or just above Havana.

General Conclusions.

The preceding brief sketch of the differences in physical conditions and the fluctuations in amount undergone by the principal elements of the plankton in the different region of the river will have served to call attention to one or two interesting facts. The upper and lower sections, we have seen, agree substantially in exhibiting a lowness of plankton production that is markedly in contrast with the condition in the middle section. In the middle section we have found, in turn, a remarkable rise in production which extends clearly to all portions of the micro-fauna and flora except the Protozoa.

We find further, on looking to the differences in situation and environment corresponding to these differences in abundance, that the larger amounts of the middle section occur associated in that region with a peculiar combination of physical conditions, which are themselves quite in contrast with the situation in the regions above and below. The task of separating the various factors that are at work in producing the changes observed in the amount of the plankton in different regions, and of assigning to each one of them its proper share of importance therein is, however, well nigh an impossible one. These factors are in the present instance not few, are variously and at times interchangeably important, and are in most cases inextricably complicated with one another. We mention the following as more or less important: the food supply, made up of the living and dead organic material, the nutrient inorganic substance, and the

various chemical products of putrefaction carried by the stream; the lakes and sloughs communicating with the stream and contributing variously to the origin and the maintenance of its plankton population; the effects of dilution from tributary streams poor in plankton; the effects of rainfall and ensuing flood; and, less important in the case before us, the effects of depth, speed of current, and temperature.

The role played by organic waste in the food supply of the microorganisms of fresh water, and the importance of these organisms in the destruction of the products of decay have been discussed by various writers and need not occupy us here. In conformity thereto we find that the high plankton production of the middle section and the low production characteristic of the upper and lower occur side by side with corresponding differences in the amount of organic waste present. There can hardly be a question that the great contamination of the waters of the Illinois by the waste introduced at Peoria bears an important relation to the immense rise in the plankton that distinguishes the middle section. It is, however, impossible to separate the effects of the Peoria sewage from that of contributions from Peoria Lake, which, owing to its more or less distinctly lacustrine character, should furnish in favorable seasons a good breeding ground for the species of the plankton. Such a separation might be made if the collection begun 6 miles above Pekin had been interrupted at Peoria instead of 7 miles above. Recent collections made in October 1902, toward the close of a period of high water, indicate that the rise in the Peoria section begins immediately below the city of Peoria and not in the lake. The extent to which the lake had been washed out during the rains preceding

the trip of May, 1899, does not appear from any data at hand.

An interesting feature of the situation is disclosed by a comparison of the fluctuations undergone by the Algae, Rotifera and Entomostraca in the different regions of the river, and has been described by Professor Forbes in words which we quote below. "The rise and fall are seen to be very much the largest in the Algae, smallest in the Entomostraca, and intermediate in the Rotifera, - a fact which is probably related to the order of dependence of these three groups one upon another for food; and dependent also, doubtless, to some extent, upon the rapidity of their multiplication. As the Algae multiply much more rapidly than the Rotifera they become vastly more abundant relatively under the favorable conditions supplied by the middle section, and as the Rotifera multiply more rapidly than the Entomostraca they likewise react more quickly and strongly first to the favorable and then to the unfavorable conditions supplied by the middle and lower sections respectively. As a further consequence the Entomostraca, while not rising, in the middle section, so far above their average numbers for the whole river, remain above that average longer than do the Rotifera, and these longer than do the Algae. The Algae drop below the average after the Peoria outbreak, at about the fourth or fifth station below that point; while the Rotifera cross the average line between the sixth and seventh stations; and the Entomostraca between the tenth and eleventh." Reference may be made in this connection to the diagram at the conclusion.

The extent of contribution from neighboring lakes and sloughs to the plankton population of the river can be satisfactorily estimated only after making exhaustive comparative studies of col-

lections from the lakes, from the main stream between them, and from the points where these bodies discharge into the river. Barely a beginning of this work has yet been accomplished. A study of collections from Beckish, Phelps and Thompson's lakes, which are isolated from the river except in flood season, has indicated that these lakes produce in the spring season an amount of plankton per cubic meter which is generally vastly in excess of that found in the upper and lower portions of the river and also generally well above production in the middle section, as shown in the collections of the plankton trip. The relatively greater production of plankton by lakes than by the river at the same season, the similar constitution of the lake and river plankton, and the fact that at the period when the collections which form the subject of the present paper were made river levels were such as to encourage contribution from the most directly communicating lakes of the middle region, are all in favor of assigning some importance to such contributions in assisting to maintain the maximum of plankton production which has its origin in the region of Peoria. It is a fact worthy of note that while the rise in the Peoria region is sudden and the diminution by the time Pekin is reached extensive, the plankton remains without important diminution between Pekin and Havana, the Rotifera and Entomostraca even exhibiting a rise at the last named station. This degree of productiveness, maintained below Pekin in spite of a falling food supply (except as this is afforded by the plankton itself) and a dilution of some amount from plankton-poor tributaries between Pekin and Havana, may be due to some extent to contribution from the neighboring lakes as well as to continued multiplication in the plankton itself. It is carried southward with the sluggish current.

Dilution is doubtless one of the most important factors to be considered in explanation of the quantitative variations in the plankton of the Illinois river. Its real effects are obscured, however, by the work of other local conditions, to some of which we have already referred. The question is further complicated by the fact that the failure of water from a tributary to combine promptly and evenly with that of the stream which it enters may lead to erroneous conclusions in regard to dilution if the collections be taken either from the recently received water or from outside of the tributary flow.

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Tables.

Except in the case of a few representative species, group totals only are given in the tables that follow. The word "Disc" refers to the turbidity of the water as measured by a porcelain plate, its distance under water at disappearance constituting our measurement of turbidity.

LIST OF COLLECTIONS.

Accession Number.	Location.	Disc.	Temp.(Fahr.).
22,861	Grafton to Otter Creek	15.0 Cm.	73°
22,862	Otter Creek to Hardin		
22,863	Hardin to Kampsville	8.0	71°
22,864	Kampsville to Grand Pass		
22,865	Grand Pass to Florence	2.5	68
22,866	Florence to Mauvaise Terre Creek		
22,867	Mauvaise Terre Creek to Meredosia	3.5	66°
22,868	Meredosia to LaGrange		
22,869	LaGrange to Beardstown	3.5	
22,870	Beardstown to Browning		
22,871	Browning to Holmes' Landing	5.0	
22,872	Holmes' Landing to Havana		
22,873	Havana to Liverpool	4.0	67°
22,874	Liverpool to 2 mi. abv. Copperas Cr.	4.0	68°
22,875	2 mi. abv. Copperas Cr. to Mackinaw Cr.	5.0	67°
22,876	Mackinaw Cr. to 3 mi. abv. Pekin	6.0	67°
22,877	3 mi. abv. Pekin to 7 mi. abv. Peoria	8.0	66°
22,878	7 mi. abv. Peoria to Chillicothe	12.0	65°
22,879	Chillicothe to Lacon	15.0	66°
22,880	Lacon to Henry		
22,881	Henry to Hennepin	20.0	66°

ALVA.

Acc. No.	<i>Polistroma partitum</i>	<i>Melosira gran- ulate spinosa</i>	Gran. Total of Alva.
22,861.	5,800	2,478,600	2,654,000
22,862.	1,000	2,680,500	
22,863.	13,800	1,605,100	1,730,300
22,864.	(part of collection lost)		
22,865.	2,500	2,255,500	2,255,500
22,866.	6,000	5,034,900	
22,867.	5,200	4,953,600	5,285,700
22,868.	16,800	10,606,400	
22,869.	40,000	10,462,200	10,941,800
22,870.	57,200	7,879,600	
22,871.	48,000	11,130,200	11,278,300
22,872.	31,200	23,616,000	
22,873.	272,200	18,291,300	19,508,200
22,874.	43,200	21,591,400	23,929,400
22,875.	64,000	19,008,000	19,800,200
22,876.	172,800	25,152,800	28,454,800
22,877.	108,000	87,717,600	91,087,500
22,878.	27,600	5,549,000	6,073,300
22,879.	18,000	2,857,600	4,822,700
22,880.	31,200	3,405,600	
22,881.	32,000	4,326,900	6,310,600

PROTOZOA.

Acc. No.	Codonella cratara	Grand Total of Protozoa
22,861.	17,700	28,700
22,862.	44,100	
22,863.	57,600	212,600
22,864		
22,865.	15,800	42,500
22,866.	7,200	
22,867.	31,200	69,300
22,868.	38,400	
22,869.	57,200	103,000
22,870.	40,800	
22,871.	14,800	44,600
22,872.	21,600	
22,873.	37,800	54,600
22,874.	14,400	40,800
22,875.	34,000	130,200
22,876.	14,400	60,000
22,877.	27,600	48,000
22,878.	4,200	18,200
22,879.	19,200	33,300
22,880.	6,000	
22,881.	9,000	37,200

NOTES.

App. No.	Polvarthen platyptera.	Brachioris angulalis.	aurora cochlearis.	Grand Totals of Retifera Eggs, free & Individuals carried.
22,861.	3,400.	6,800.	7,100.	20,000. . . 81,100
22,862.				. . . 32,600
22,863.	1,000.	18,000.	28,400.	48,400. . . 84,300
22,864.				
22,865.	1,000.	10,500.	9,000.	20,000. . . 27,700
22,866.				. . . 74,400
22,867.	3,000.	17,400.	14,000.	48,600. . . 55,200
22,868.				. . . 98,600
22,869.	5,800.	36,400.	20,000.	66,500. . . 106,700
22,870.				. . . 146,400
22,871.	11,400.	74,000.	52,100.	83,200. . . 181,500
22,872.				. . . 194,400
22,873.	60,000.	212,800.	105,600.	515,000. . . 588,700
22,874.	20,000.	70,400.	44,800.	400,100. . . 307,600
22,875.	7,200.	160,800.	38,800.	248,300. . . 476,000
22,876.	17,600.	129,600.	16,000.	361,300. . . 388,200
22,877.	28,000.	184,800.	35,200.	507,700. . . 672,200
22,878.	6,000.	9,000.	9,000.	40,500. . . 109,200
22,879.	5,400.	5,100.	19,500.	62,500. . . 82,600
22,880.				. . . 85,200
22,881.	7,400.	2,400.	12,800.	61,900. . . 57,300

ENTOMOSTRACA.

Acc.No.	Bosmina longirostris.	Chydorus sphaericus.	Cyclops.*	Nauplii.	Grand Total of Entomostraca
22,861.	1,450.	100.	1,200.	8,300.	12,075
22,862.				3,450.	8,400
22,863.	2,900.	300.	1,525.	1,680.	8,805
22,864.					
22,865.	5,750.	600.	5,600.	12,000.	28,500
22,866.				31,200.	50,400
22,867.	5,600.	650.	8,100.	38,000.	54,350
22,868.				40,800.	61,150
22,869.	7,900.	1,150.	7,850.	39,200.	61,400
22,870.				69,600.	94,800
22,871.	11,650.	1,600.	18,400.	38,600.	77,350
22,872.				64,800.	108,000
22,873.	18,400.	2,300.	27,400.	102,000.	154,900
22,874.	14,100.	3,100.	19,100.	39,200.	79,400
22,875.	5,850.	2,050.	7,200.	68,800.	85,450
22,876.	6,500.	1,300.	14,800.	36,000.	60,700
22,877.	3,900.	1,700.	8,100.	122,400.	138,000
22,878.	1,800.	475.	3,450.	22,800.	28,900
22,879.	1,100.	350.	2,325.	56,400.	60,370
22,880.				18,000.	25,200
22,881.	2,200.	300.	6,000.	32,000.	41,000

* Not including Nauplii





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